WHAT IS CLAIMED IS:

1. A method for operating a precision machine vision inspection system to determine an estimated best focus position that is at least approximately a best focus position usable for inspecting a region of interest of a workpiece, the precision machine vision inspection system comprising:

an imaging system comprising:

a camera having a pixel set corresponding to a full field of view of the camera, the camera operable to output the pixel values of at least one configuration of a reduced readout pixel set, the at least one configuration of a reduced readout pixel set corresponding to substantially less than the full field of view of the camera along at least one dimension of the field of view of the camera, and

at least one lens configuration;

a plurality of controllable motion axes including a focus axis, the focus axis including a focus axis position sensor;

a control system portion; and

a workpiece stage that carries the workpiece, wherein at least one of the workpiece stage and the imaging system is movable to provide relative motion with respect to the other at least along the focus axis, the method comprising:

overlapping at least a majority of the region of interest and at least part of a reduced readout pixel set in the field of view of the camera;

providing a motion, the motion including traversing a focus image range along the focus axis direction using continuous motion;

inputting an auto focus image into the camera during the continuous motion, the auto focus image having a respective effective exposure time and exposure duration;

outputting the pixel values of the reduced readout pixel set of the auto focus image to the control system portion during the continuous motion, the output pixel values of the auto focus image corresponding to substantially less than the full field of view of the camera along at least one dimension of the field of view of the camera;

repeating the inputting and outputting steps to provide data for a plurality of reduced readout pixel sets corresponding to a plurality of auto focus images distributed along the focus image range;

determining respective positions along the focus axis for at least some of the plurality of auto focus images; and

determining an estimated best focus position that is at least approximately the best focus position usable for inspecting a region of interest of a workpiece based on at least some of the data for a plurality of reduced readout pixel sets and at least some of the respective positions along the focus axis for at least some of the plurality of auto focus images, wherein:

the output pixel values of the outputting operation are output in a time that is substantially less than a time required for outputting the full pixel set corresponding to a full field of view of the camera;

repeating the inputting and outputting steps is performed within a reduced time that is less than a standard time that corresponds to inputting an input image and outputting a pixel set corresponding to a full field of view of the camera;

the plurality of auto focus images are distributed along the focus image range in a manner depending at least partially on the reduced time and the provided motion such that a maximum spacing along the focus axis between the respective positions of adjacent auto focus images is operational for determining the estimated best focus position that is at least approximately the best focus position to a desired level of accuracy; and

the motion over at least a part of the focus image range is substantially faster than a fastest motion allowable in combination with the standard time in order to hypothetically produce adjacent auto focus images that are spaced apart along the focus axis direction by that maximum spacing between the respective positions of adjacent auto focus images.

2. The method of claim 1, wherein the motion over at least a part of the focus image range is at least 2.5 times faster than a fastest motion allowable in combination with the standard time in order to

hypothetically produce adjacent auto focus images that are spaced apart along the focus axis direction by that maximum spacing between the respective positions of adjacent auto focus images.

3. The method of claim 1, wherein the motion over at least a part of the focus image range is at least five times faster than a fastest motion allowable in combination with the standard time in order to hypothetically produce adjacent auto focus images that are spaced apart along the focus axis direction by that maximum spacing between the respective positions of adjacent auto focus images.

4. The method of claim 1, wherein the motion over at least a part of the focus image range is at least 90% as fast as the fastest motion allowable in combination with the reduced time in order to hypothetically produce a maximum spacing between the respective positions of adjacent auto focus images that is equal to a predetermined limit.

5. The method of claim 4, wherein the method is operable in at least one a lower accuracy mode and at least one higher accuracy mode, and when the method is operated in at least one lower accuracy mode, the value of the predetermined limit is equal to at least 0.2 times and at most 0.5 times the full-width-half-maximum width of the expected nominal focus curve width for a current lens configuration, and, when the method is operated in at least one higher accuracy mode, the value of the predetermined limit is equal to at least 0.02 times and at most 0.1 times the full-width-half-maximum width of the expected nominal focus curve width for a current lens configuration.

6. The method of claim 4, wherein the method is operable in at least one a lower accuracy mode and at least one higher accuracy mode, and when the method is operated in at least one lower accuracy mode, the value of the predetermined limit in microns is equal to at least $(0.18/NA^2)$ and at most $(0.45/NA^2)$, where NA is an effective numerical aperture of a current lens configuration, and, when the auto focus tool is operated in at least one higher accuracy mode, the value of the predetermined limit in microns is equal to at least $(0.018/NA^2)$ and at most $(0.09/NA^2)$.

7. The method of claim 1, wherein the at least a majority of the region of interest comprises all of the region of interest.

8. The method of claim 1, wherein the at least one configuration of a reduced readout pixel set comprises a set of pixels having at least one of a selectable location and a selectable range along at least one dimension of the field of view of the camera and the overlapping step comprises operating the camera according to at least one of a selected location and a selected to range that overlaps the reduced readout pixel set with the at least a majority of the region of interest.

9. The method of claim 1, wherein the at least one configuration of a reduced readout pixel set comprises a set of pixels having a span that is fixed relative to the field of view of the camera along the at least one direction and the aligning step comprises positioning of the workpiece relative to the imaging system according to a position that overlaps the at least a majority of the region of interest with the reduced readout pixel set.

10. The method of claim 1, wherein determining respective positions along the focus axis comprises determining a respective position output of at least the focus axis position sensor corresponding to each of the at least some of the plurality of auto focus images, each respective position output having a timing that is correlated to the corresponding respective effective exposure time.

11. The method of claim 10, wherein the respective position output and the output pixel values corresponding to each of the at least some of the plurality of auto focus images are stored by the control system portion and determining the focus axis position is completed after all of the respective position outputs and the output pixel values corresponding to each of the at least some of the plurality of auto focus images are stored.

12. The method of claim 10, wherein a respective first control signal determines the start of each effective exposure duration and determining the respective position output comprises capturing the respective position output with a deterministic timing relative to the respective first control signal.

13. The method of claim 12, wherein the respective first control signal determines the start of one of a) a respective electronic shutter duration of the camera that determines the respective effective exposure

duration, and b) a respective strobe illumination duration that determines the respective effective exposure duration.

14. The method of claim 13, wherein at least one of the continuous motion and the respective effective exposure duration are provided such that for each respective auto focus image the maximum motion along the focus axis is at most equal to at least one of a) a predetermined exposure motion limit, b) 0.25 times the predetermined spacing limit, c) 0.5 microns, and d) 0.25 microns.

15. The method of claim 14, wherein the continuous relative motion includes an acceleration and at least some of the auto focus images are input during the acceleration.

16. The method of claim 1, wherein the continuous relative motion includes an acceleration and at least some of the auto focus images are input during the acceleration.

17. The method of claim 16, wherein at least one of the continuous motion and the respective effective exposure duration are provided such that for each respective auto focus image the maximum motion along the focus axis is at most equal to at least one of a) a predetermined exposure motion limit, b) 0.25 times the predetermined spacing limit, c) 0.5 microns, and d) 0.25 microns.

18. The method of claim 1, comprising:

performing at least the providing, inputting, outputting, repeating, determining respective positions, and determining the estimated best focus position steps a first time over a relatively larger focus image range with a relatively larger maximum spacing, wherein determining the estimated best focus position comprises determining a relatively more approximate focus position; and

performing at least the providing, inputting, outputting, repeating, determining respective positions, and determining the estimated best focus position steps a second time over a relatively smaller focus image range including the determined relatively more approximate focus position with a relatively smaller maximum spacing, wherein determining the estimated best focus position step comprises determining a relatively

less approximate focus position, and the less approximate focus position is used for inspecting the workpiece, at least in the region of interest.

19. The method of claim 1, wherein the focus axis position is set at the determined estimated best focus position that is at least approximately the best focus position, an inspection image is acquired at that position, and that inspection image is used for inspecting the workpiece, at least in the region of interest.

20. The method of claim 1, wherein the determined estimated best focus position that is at least approximately the best focus position is used as a feature coordinate value for a feature to be inspected in the region of interest without actually setting the focus axis position of the precision machine vision inspection system at that position.

21. The method of claim 20, wherein the respective reduced readout pixel set data having the respective position along the focus axis that is closest to the determined estimated best focus position that is at least approximately the best focus position is used for inspecting the workpiece in the region of interest without actually setting the focus axis position of the precision machine vision inspection system at that focus position.

22. A method of training mode operation for a precision machine vision inspection system in order to determine set of machine control instructions usable to automatically determine an estimated best focus position that is at least approximately a best focus position usable for inspecting a region of interest of a workpiece, the precision machine vision inspection system comprising:

an imaging system comprising:

a camera having a pixel set corresponding to a full field of view of the camera, the camera operable to output the pixel values of at least one configuration of a reduced readout pixel set, the at least one configuration of a reduced readout pixel set corresponding to substantially less than the full field of view of the camera along at least one dimension of the field of view of the camera, and

at least one lens configuration;

a plurality of controllable motion axes including a focus axis, the focus axis including a focus axis position sensor;

a control system portion;

a workpiece stage that carries the workpiece, wherein at least one of the workpiece stage and the imaging system is movable to provide relative motion with respect to the other at least along the focus axis; and

a graphical user interface comprising a display portion usable to display workpieces images, and a plurality of user interface elements comprising at least one auto focus tool, the method comprising:

defining a region of interest and a reduced readout pixel set overlapping with at least a majority of the region of interest, wherein:

at least the region of interest is defined using an auto focus widget associated with the operation of an auto focus tool, the auto focus widget positionable on a displayed image of the workpiece,

the output pixel values correspond to substantially less than the full field of view of the camera along at least one dimension of the field of view of the camera, and

the pixel values of the reduced readout pixel set of an auto focus image can be output to the control system portion in a time that is substantially less than a time required for outputting the full pixel set corresponding to a full field of view of the camera;

defining a set of auto focus parameters usable to determine a set of auto focus operations for the region of interest;

determining a set of auto focus operations for the region of interest, comprising:

determining a run mode focus image range,

determining a run mode auto focus motion; the auto focus motion including traversing the focus image range along the focus axis direction using continuous motion, and

determining a run mode illumination level and exposure duration usable for inputting an auto focus image into the camera during the continuous motion;

providing operations to determine a repetitive inputting of respective auto focus images and outputting of respective data for a plurality of reduced readout pixel sets corresponding to a plurality of auto focus images distributed along the focus image range during the continuous motion, each of the respective auto focus images having an effective exposure time and exposure duration;

providing operations to determine respective positions along the focus axis for at least some of the plurality of auto focus images; and

providing operations to determine the estimated best focus position that is at least approximately the best focus position usable for inspecting a region of interest of a workpiece based on at least some of the data for a plurality of reduced readout pixel sets and at least some of the respective positions along the focus axis for at least some of the plurality of auto focus images, wherein:

the determined repetitive inputting of respective auto focus images and outputting of respective data for a plurality of reduced readout pixel sets is performed within a reduced time that is less than a standard time that corresponds to inputting an input image and outputting a pixel set corresponding to a full field of view of the camera;

the plurality of auto focus images are distributed along the focus image range in a manner depending at least partially on the reduced time and the auto focus motion such that a maximum spacing along the focus axis between the respective positions of adjacent auto focus images is operational for determining the estimated best focus position that is at least approximately the best focus position to a desired level of accuracy; and

the auto focus motion is substantially faster along the focus axis over at least a part of the focus image range than a fastest motion allowable in combination with the standard time in order to hypothetically produce that maximum spacing between the respective positions of adjacent auto focus images.

23. The method of claim 22, wherein the auto focus motion is at least 2.5 times faster along the focus axis over at least a part of the focus

image range than a fastest motion allowable in combination with the standard time in order to hypothetically produce that maximum spacing between the respective positions of adjacent auto focus images.

24. The method of claim 22, wherein the auto focus motion over at least a part of the focus image range is at least 90% as fast along the focus axis as the fastest motion allowable in combination with the reduced time in order to hypothetically produce a maximum spacing between the respective positions of adjacent auto focus images that is equal to a predetermined limit.

25. The method of claim 22, wherein the maximum spacing along the focus axis between the respective positions of adjacent auto focus images is at most equal to a predetermined limit.

26. The method of claim 25, wherein the predetermined limit is determined based on at least one lens characteristic of a current lens configuration.

27. The method of claim 26, wherein the lens characteristic includes one of a) an expected nominal focus curve width for the current lens configuration and b) a characteristic that at least partially determines an expected nominal focus curve width for the current lens configuration, and the predetermined limit is effectively approximately proportional to the expected nominal focus curve width for the current lens configuration.

28. The method of claim 25, wherein the auto focus tool includes a plurality of accuracy modes and when the auto focus tool is operated in a first one of the accuracy modes the value of the predetermined limit is equal to at least 0.2 times and at most 0.5 times the full-width-half-maximum width of the expected nominal focus curve width for a current lens configuration and when the auto focus tool is operated in a second one of the accuracy modes the value of the predetermined limit is equal to at least 0.02 times and at most 0.1 times the full-width-half-maximum width of the expected nominal focus curve width for a current lens configuration

29. The method of claim 25, wherein the auto focus tool includes a plurality of accuracy modes and when the auto focus tool is operated in a first one of the accuracy modes the value of the

predetermined limit in microns is equal to at least ($0.18/NA^2$) times and at most ($0.45/NA^2$), where NA is an effective numerical aperture of a current lens configuration and when the auto focus tool is operated in a second one of the accuracy modes the value of the predetermined limit in microns is equal to at least ($0.018/NA^2$) times and at most ($0.09/NA^2$).

30. The method of claim 22, wherein the control system portion automatically defines a reduced readout pixel set that overlaps with at least a majority of the region of interest.

31. The method of claim 30, wherein the reduced readout pixel set is substantially identical to the region of interest.

32. The method of claim 22, wherein the at least one configuration of a reduced readout pixel set includes a reduced readout pixel set having a predetermined size and shape and for at least a portion of the time that the auto focus tool widget is displayed on the image of the workpiece, a widget having the predetermined size and shape is also displayed to indicate the location of the reduced readout pixel set.

33. The method of claim 32, wherein a region of interest indicating portion of the auto focus tool widget includes a display of the region of interest boundaries, and when a boundary of the region of interest indicating portion extends outside of the indicated location of the reduced readout pixel set, a graphical user interface element is automatically activated to highlight that condition.

34. The method of claim 22, wherein the at least one configuration of a reduced readout pixel set includes a configuration having at a span along at least one direction that is fixed relative to the field of view of the camera along the at least one direction, and when a region of interest is defined outside of the span, the control system portion is operable to automatically generate at least one machine control instruction that positions the at least a majority of the region of interest within the span along the at least one direction.

35. The method of claim 34, wherein the graphical user interface displays a control widget operable by a user to trigger the operation that automatically generates the at least one machine control

instruction that positions the at least a majority of the region of interest within the span along the at least one direction.

36. The method of claim 22 wherein the determination of respective positions along the focus axis comprises inputting to the control system portion a respective position signal of at least the focus axis position sensor for at least some of the plurality of auto focus images, each respective position signal corresponding to an effective timing that is correlated to the corresponding respective effective exposure time.

37. The method of claim 36, wherein the continuous motion includes an acceleration and at least some of the auto focus images are input during the acceleration.

38. The method of claim 22, wherein the precision machine vision inspection system further comprises at least one controllable illumination source that is operable in both a constant illumination mode and a strobe illumination mode, and determining a set of auto focus parameters comprises:

operating at least one controllable illumination source in the constant illumination mode during a known camera exposure duration to determine an acceptable total exposure illumination energy usable for inputting an auto focus image into the camera; and

determining strobe control parameters that determine an illumination level and an effective exposure duration usable for inputting an auto focus image into the camera during the continuous motion using the strobe illumination, wherein the strobe illumination level and exposure duration provide at least approximately the same total exposure illumination energy as the continuous illumination.

39. The method of claim 38, wherein the control system portion automatically determines the strobe control parameters based on the total exposure illumination energy provided by the continuous illumination.

40. The method of claim 39, wherein the control system portion automatically determines the strobe duration such that the motion along the focus axis during the strobe duration is at most equal to at least one of a) a predetermined exposure motion limit along the focus axis, b) 0.25 times the predetermined spacing limit, c) 0.5 microns, and d) 0.25 microns.

41. The method of claim 38, further comprising providing a training mode demonstration that automatically executes operations substantially functionally similar to the determined operations and displays an image acquired at the resulting determined estimated best focus position that is at least approximately the best focus position for user evaluation.

42. The method of claim 22, the method further comprising providing operations that, based at least partially on the estimated best focus position, automatically:

determine a shorter auto focus image range;

determine a shorter auto focus motion; the shorter auto focus motion including traversing the shorter focus image range along the focus axis direction using continuous motion;

use the determined illumination level and exposure duration and determine a repetitive inputting of respective auto focus images and outputting of respective data for a plurality of reduced readout pixel sets corresponding to a plurality of auto focus images distributed along the shorter focus image range during the continuous motion, each of the respective auto focus images having an effective exposure time and exposure duration;

determine respective positions along the focus axis for at least some of the plurality of auto focus images distributed along the shorter focus image range; and

determine a refined estimated best focus position that is at least approximately the best focus position usable for inspecting the region of interest of a workpiece based on at least some of the data for a plurality of reduced readout pixel sets and at least some of the respective positions along the focus axis for at least some of the plurality of auto focus images distributed along the shorter focus image range;

wherein the operations performed over the shorter focus image range provide a shorter maximum spacing, the refined estimated best focus position is relatively less approximate, and the refined estimated best focus position is used for inspecting the workpiece, at least in the region of interest.

43. The method of claim 22, wherein method further comprises providing operations that set the focus axis position at the estimated best focus position , acquire an inspection image at that position, and use that inspection image for inspecting the workpiece, at least in the region of interest.

44. The method of claim 22, wherein the method further comprises providing operations that set the estimated best focus position that is at least approximately the best focus position as a feature coordinate value for a feature to be inspected in the region of interest without actually setting the focus axis position of the precision machine vision inspection system at that position.

45. The method of claim 22, wherein the method further comprises providing operations that select the respective reduced readout pixel set data having the respective position along the focus axis that is closest to the estimated best focus position, and use that respective reduced readout pixel set data for inspecting the workpiece in the region of interest without actually setting the focus axis position of the precision machine vision inspection system at that estimated best focus position.

46. The method of claim 22, further comprising generating and storing the set of machine control instructions based on the method.

47. The method of claim 22, further comprising providing a demonstration sequence in the training mode that automatically executes operations substantially functionally similar to the determined operations and displays an image acquired at the resulting estimated best focus position for user evaluation.

48. The method of claim 47, wherein the graphical user interface displays a control widget operable by a user to trigger the demonstration sequence.